

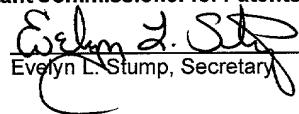
U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE FORM PTO-1390 (REV 10-2000)		ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		AZ.2657
INTERNATIONAL APPLICATION NO. PCT/EP99/08534	INTERNATIONAL FILING DATE 6 November 1999	U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/831842 Unknown
TITLE OF INVENTION METHOD FOR DETERMINING THE THICKNESS OF A MULTI-THIN-LAYER STRUCTURE		
APPLICANT(S) FOR DO/EO/US Dr. Rolf Hertling, Wolfgang Schaudig, Dr. Wilbert Windelm		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:		
<ol style="list-style-type: none"> <li><input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li><input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li><input checked="" type="checkbox"/> This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).</li> <li><input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).</li> <li><input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))             <ol style="list-style-type: none"> <li><input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</li> <li><input checked="" type="checkbox"/> has been communicated by the International Bureau.</li> <li><input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</li> </ol> </li> <li><input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</li> <li><input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))             <ol style="list-style-type: none"> <li><input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</li> <li><input type="checkbox"/> have been communicated by the International Bureau.</li> <li><input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</li> <li><input type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li><input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</li> <li><input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</li> <li><input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</li> </ol>		
Items 11 to 16 below concern document(s) or information included:		
<ol style="list-style-type: none"> <li><input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.</li> <li><input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</li> <li><input checked="" type="checkbox"/> A <b>FIRST</b> preliminary amendment.</li> <li><input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment.</li> <li><input type="checkbox"/> A substitute specification.</li> <li><input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li><input type="checkbox"/> Other items or information:</li> </ol>		
<p style="text-align: center;">"Express Mail" Mailing Label Number EL 490 188 838 US</p> <p>Date of Deposit <u>May 11, 2001</u></p> <p>I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of patents and trade marks, Washington, D.C. 20231</p> <p style="text-align: right;"><u>Evelyn L. Stump</u> Evelyn L. Stump, Secretary</p>		

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO PCT/EP99/08534	ATTORNEY'S DOCKET NUMBER A-2657																
17. <input type="checkbox"/> The following fees are submitted: <b>BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5) ):</b> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... <b>\$1000.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... <b>\$860.00</b> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... <b>\$710.00</b> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... <b>\$690.00</b> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... <b>\$100.00</b>		<b>CALCULATIONS</b> PTO USE ONLY																
<b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b>		<b>\$ 860.00</b>																
Surcharge of <b>\$130.00</b> for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		\$																
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">CLAIMS</th> <th style="width: 30%;">NUMBER FILED</th> <th style="width: 30%;">NUMBER EXTRA</th> <th style="width: 25%;">RATE</th> </tr> </thead> <tbody> <tr> <td>Total claims</td> <td>- 20 =</td> <td></td> <td>X \$18.00</td> </tr> <tr> <td>Independent claims</td> <td>- 3 =</td> <td></td> <td>X \$80.00</td> </tr> <tr> <td colspan="2" style="text-align: center;">MULTIPLE DEPENDENT CLAIM(S) (if applicable)</td> <td></td> <td>+ \$270.00</td> </tr> </tbody> </table>		CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	Total claims	- 20 =		X \$18.00	Independent claims	- 3 =		X \$80.00	MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00	\$
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Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). <b>\$40.00</b> per property		\$																
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a. <input checked="" type="checkbox"/> A check in the amount of <b>\$ 860.00</b> to cover the above fees is enclosed.																		
b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$_____ to cover the above fees. A duplicate copy of this sheet is enclosed.																		
c. <input type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>02-1653</u> . A duplicate copy of this sheet is enclosed. In the event there is any discrepancy in the amount sent herewith or at any time in the future please charge any additional fee, credit or overpayment to the above deposit account number. <b>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</b>																		
SEND ALL CORRESPONDENCE TO:  <b>ROBERT W. BECKER &amp; ASSOCIATES</b> <b>11896 N. HIGHWAY 14 SUITE B</b> <b>TIJERAS, NEW MEXICO 87059</b>																		
<u>Robert ~ Becker</u> SIGNATURE: <u>Robert W. Becker</u> NAME <u>26,255</u> REGISTRATION NUMBER																		

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Evelyn L. Stump, Secretary

In the Application of Dr. Rolf Hertling, et al.

Ser.No.: Not Yet Known (based on DE 198 52 323.8 filed 12 November 1998 and PCT/EP99/08534 filed 6 November 1999)

International  
Filing Date: 6 November, 1999

For: METHOD FOR DETERMINING THE THICKNESS OF A MULTI-THIN-LAYER STRUCTURE

Box PCT  
Assistant Commissioner for Patents  
Washington, DC 20231

**PRELIMINARY AMENDMENT ACCOMPANYING ENTRY INTO  
NATIONAL STAGE APPLICATION**

Sir:

Prior to examination, please amend the above-identified application as follows.

**IN THE SPECIFICATION:**

On page 1, immediately after the title, please insert the following heading:

--Background of the Invention--.

On page 2 between lines 5 and 6, please insert the following heading:

--Summary of the Invention--.

Page 7 between lines 16 And 17 please insert the following heading:

--Brief Description of the Drawings--.

On page 8, between lines 2 and 3, please insert the following heading:

--Description of Preferred Embodiments--;

On page 10, line 8, please change "3" to --2--.

On page 13, at the bottom of the page, please insert the following paragraphs:

--The specification incorporates by reference the disclosure of German priority documents 198 52 323.8 of 12 November 1998 and PCT/EP99/08534 of 6 November 1999.

The present invention is, of course, in no way restricted to the specific disclosure of the specification and drawings, but also encompasses any modifications within the scope of the appended claims.--

**IN THE CLAIMS:**

Please cancel claims 1 - 10, and replace them with the attached claims 11 - 19.

**REMARKS**

Claims 11 - 19 are pending in the application.

Appropriate headings have been added to the specification, and the claims from the literal translation have been replaced by claims drafted in conformity with U.S. Patent practice.

The application in its amended state is believed to be in condition for allowance. However, should the Examiner have any comments or suggestions, or wish to discuss the merits of the application, the undersigned would very much welcome a telephone call in order to be able to expedite placement of the application into condition for allowance.

Respectfully submitted,

  
\_\_\_\_\_  
Robert W. Becker Reg. No. 26,255  
for Applicant(s)

ROBERT W. BECKER & ASSOCIATES  
11896 N. Highway 14, Suite B  
Tijeras, New Mexico 87059

Telephone: (505) 286-3511  
Facsimile: (505) 286-3524

RWB:els

WHAT WE CLAIM IS:

11. A method for determining the thickness of at least one layer of a substrate that has geometric structures that lead to diffraction of light, including the steps of:

5 measuring at least one of the reflection and the transmission light intensity values of zero order of diffraction as a function of wavelength;

10 calculating the at least one of reflection and transmission light intensity values using an iteration model in which the individual layer parameters and the geometric dimensions of said geometric structures of said substrate are included as further parameters; and

modifying the parameters to effect correspondence between the measured and calculated values.

12. A method according to claim 11, wherein geometric dimensions of said geometric structures of said substrate are determined.

13. A method according to claim 11, wherein at least one of calculated data for layer thicknesses and for said geometric structures are used for regulating production processes for at least one of applying at least one layer to a substrate and for developing substrate structures.

20 14. A method according to claim 11, wherein the substrates are blanks for data storage media.

15. A method according to claim 14, wherein said geometric structures are channels in said blank.

16. A method according to claim 11, wherein at least one layer is an information-carrying layer.

5 17. A method according to claim 16, wherein said information-carrying layer is a metal alloy that is modifiable by energy from a beam of light between two phases.

18. A method according to claim 16, wherein said information-carrying layer is formed between two buffer layers.

10 19. A method according to claim 11, wherein optical data storage media are used during manufacturing.

31 PRTS

METHOD FOR DETERMINING THE THICKNESS OF  
A MULTI-THIN-LAYER STRUCTURE

The invention relates to a method for determining the thickness  
5 of at least one layer provided on a substrate.

When applying layers to a substrate, it is necessary that a certain layer thickness must be created or maintained. This is particularly true for the manufacture of storage media, in particular optical data storage media such as CDs, CD-Rs, DVDs, CD-RWs, 10 DVD-RWs, MOs, and other data storage media to which different layers, such as information carrier layers, protective layers, or reflection layers, are applied. Known for measuring the layer thicknesses for quality control and during the production process are various layer thickness measurement processes, but these processes cannot be employed on grooved substrates. For determining groove geometry, 15 reflection and/or transmission are measured for various orders of diffraction. However, such measurement processes with higher orders of diffraction of the light require more complex measurement equipment and calibration measures. It is not possible, or it is only possible with limited accuracy, to measure the layer thicknesses if the 20 substrate itself has structures such as troughs that in optical storage media, for instance, are called grooves and that are required for writing, reading, and/or deleting data.

The object of the invention is therefore to create a method that 25 provides a simple and reliable measurement process, provides reliable

measurements for its control and regulation, in particular even during the layer application process, and also provides reliable measurements for substrates with structures contained therein or formed on the surface thereof, and that makes it possible to determine the structure geometry.

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The object set forth is achieved in a method for determining the thickness of at least one layer provided on a substrate by measuring reflection and/or transmission light intensity values of zero order of diffraction as a function of the wavelength and by calculating the reflection and/or transmission light intensity values using an iteration model that depends on the individual layer parameters, whereby the layer parameters are modified to effect correspondence between the measured values and the calculated values, and whereby the substrates have geometric structures, the geometric dimensions of which are used as additional parameters of the iteration model.

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In contrast to the conventional measurement processes, the inventive measures make it possible to correctly determine layer thicknesses, even of substrates with structures, as is the case, for instance, with CD blanks with grooves to which various layers must be applied, each layer having subsequently determined layer thicknesses, in order to manufacture optical data storage media. In addition, the method, and in particular the measurement device provided therefor, is very simple, because in the inventive method it is only necessary to

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measure the reflection/transmission light intensity values of the zero order of diffraction. This enables a very simple measurement arrangement that in particular can be used in the manufacturing process of, for instance, optical data carriers. Furthermore, calibrating the inventive method, in which only light values of zero order of diffraction are measured, is substantially less complex than in conventional processes. It is therefore possible to perform a wide variety of measurement processes with a single measurement device, as will be explained in more detail in the following.

In particular sample preparations are also no longer required with the inventive method, since the thickness of layers that are or will be applied to substrates with structures can be determined accurately and reliably. The process is therefore also particularly employable even during the manufacturing process, that is, it can be used in-line, since thickness measurements and controls are possible directly on the produced products, such as optical data storage media.

Thus, in accordance with the inventive method, the transmission light intensity values in reflection and/or transmission are measured spectrally, that is, as a function of the wavelength. These measurement values are then evaluated using optical calculations. This approach is to calculate the reflection and/or transmission light intensity values from optical models for a layer system and to vary in every calculation step the layer thicknesses and/or the spectral

material parameters, e.g., the refraction indices (n) and/or the absorption indices (k) until the minimum deviation between measurement and calculation is achieved. Thus a layer thickness control is possible, and therefore monitoring of the optical properties of a layer system on a substrate with structures is possible, for instance for CDs with grooves.

In accordance with all of the preferred embodiments of the invention, interferences that occur due to the geometric structures are used for additional parameters. The inventive method in accordance with this embodiment is based on calculating inphase overlap of electromagnetic partial waves on the structures, for instance, on the grooves of the substrate or blank, and therefore on the interferences of these partial waves. By varying the parameters, the width and depth of the structures, for instance the channels or grooves, can be included in the measurement process. It is not possible to achieve optical consistency between measurements and calculation unless the structure parameters, the width, the depth, and/or the intervals between the structures or channels is consistent with that of the channels on the measured sample.

Due to the spectral dependence of the changes in the reflection and/or transmission light intensity values based on the structures, that is, the channels or grooves, compared to the light intensity values without structures, the information on the structure parameters, for

instance the width, depth, and interval between channels or grooves, is already contained in the light intensity values of zero order of diffraction.

In accordance with a particularly advantageous embodiment of the invention, the geometric dimensions of the structures are determined, that is, for instance, the depth, width, and/or interval between channels or grooves. These geometric dimensions can be calculated preferably at the same time as the determination of the layer thicknesses. In this manner it is possible to monitor and control the quality of the molding process, for instance during production of optical storage media. For the special case in which no layers are applied to the substrate, that is, the layer thicknesses are zero, the measurement values for the geometric dimensions of the structures result, whereby it is thus possible to perform localized measurements of these geometric structures over the entire substrate surface in order thus to rapidly detect production errors during the production of substrates, for instance during injection molding of CD substrates.

In a very advantageous additional embodiment of the invention, the calculated data for the layer thicknesses and/or geometric structures are used for regulating production processes for applying at least one layer to a substrate and/or for developing substrate structures. The inventive method is particularly well-suited for in-line employment since in the inventive method only the light intensities of

the zero order of diffraction need to be measured, and therefore neither the measurement apparatus nor the calibration is very complex, and since a wide variety of measurement options are possible with a single measurement apparatus, for instance layer thickness measurements alone or in combination with the geometric dimensions of the substrate structures, or the geometric dimensions of the substrate structures alone. This means that during production of the optical data carriers, for instance during the manufacture of substrates, when substrate structures are being developed, or during coating of the substrate with pre-specified layer thicknesses, the inventive method can be directly employed and can be used for regulating and controlling the production process. Thus the data calculated with the inventive method for the layer thicknesses and/or the substrate structure are used for subsequently determining the values for correcting variables in the production facility. In this manner the course of production can be automatically adjusted, controlled, and regulated.

In the case of production of optical data carriers such as CDs, the inventive methods are used directly on the produced products to determine the actual values. These actual values are then directly used to provide new correcting variables, such as sputter times, sputter rates, as well as pressures, temperatures, and gas flows during the production process in the production facility. The inventive method makes it possible to input target values into the production process,

which values are then achieved via the closed loop. Since in the case of production of optical data media, in addition to the layer thicknesses, the groove geometries are also determined with the inventive method, in this manner the quality of the substrates or blanks with the geometric structures can also be controlled, that is the quality of the molding process can be controlled.

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A special case for the inventive process is when the substrates do not have a geometric structure, that is, only the layer thicknesses are measured and/or regulated.

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Preferably the substrates are blanks for data storage media such as CDs, whereby the geometric structures are formed as channels or grooves in the blank, and at least one information-carrying layer is applied to these blanks. The information-carrying layer is preferably a metal alloy that can be modified by the energy from a beam of light between two phases. The information-carrying layer is preferably formed between two buffer layers.

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The invention is explained in more detail in the following using exemplary embodiments with respect to the figures.

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Fig. 1 is a schematic representation of an optical data storage medium, in which the inventive process is employed;

Figures 2 through 4 are diagrams in which the reflection light intensity values are applied over the wavelength; and,

Fig. 5 is an exemplary embodiment for determining the locally analyzed dimensions of the substrate structures.

Figure 1 illustrates the structure of a readable, erasable, and rewritable CD, also known as a CD-RW. The following layers of layer system 2 are applied by cathode sputtering in this order to a substrate

5 1 made of polycarbonate with the thickness  $d_0$ :

a first buffer layer 3 made of a dielectric material and of a layer thickness  $d_1$  that preferably comprises a metal oxide compound;

10 an information-carrying layer 4, with the layer thickness  $d_2$ , that comprises a metal alloy and that can alternate between two phases by

means of the energy of a laser beam and that is therefore also called a fast-change layer; a second buffer layer 5 with the layer thickness  $d_3$  that is also dielectric and preferably comprises a metal oxide compound; a fourth layer 6 with a layer thickness  $d_4$  that comprises a

15 metal or a metal alloy and that draws off the energy from the laser beam that is required for writing. The two buffer layers 3 and 5 protectively enclose the information-carrying layer 4 and in addition

optimally control the optical properties of the CD-RW with respect to intensity and phase difference of the reflectance between the written and unwritten condition. The layer thicknesses of the layers 3 through

20 6 in this exemplary embodiment have the following values:  $d_1 = 96.0$  nm,  $d_2 = 20$  to 25 nm,  $d_3 = 24.0$  nm, and  $d_4 = 100$  to 130 nm.

Formed in the substrate 1 are so-called grooves 7, whereby in the illustrated exemplary embodiment, for instance, their depth is  $t = 40$  nm, their width is  $b = 570$  nm, and their periodic interval  $a$  to each other = 1600 nm.

5 The quality of such storage media depends largely on selecting  
and maintaining the correct layer thicknesses in the layer system 2 on  
the substrate 1. It is therefore necessary for the quality control and/or  
10 during the coating procedure in the in-line process to determine as  
precisely as possible the thicknesses of each of the individual layers 3  
through 6. This is achieved using the inventive process, whereby a  
beam of light 8 from a light source 9 is directed perpendicular to the  
15 substrate 1 from the side of the substrate 1 facing away from the  
applied layer. During the measurement process the wavelength of the  
beam of light 8 directed onto the substrate is modified in a wavelength  
range of approximately 400 to 1100 nm.

Figure 2 illustrates a diagram in which the reflectance of a layer construction as illustrated in Figure 1, for example, is shown as a function of the wavelength of the radiated light. In this exemplary embodiment, the substrate 1 is planar, that is, it does not have any grooves as shown in Figure 1. The curve 21 represents the calculated reflectance and the curve 22 the measured reflectance. The reflectance is calculated from initially pre-specified optical models for a layer system. Then the layer thicknesses and/or the spectral material

parameters, for instance the refractive index  $n$  or the absorption index  $k$  in the case of a transmission measurement, are varied with each calculation step until a minimum deviation is achieved between measurement and calculation, as shown in Figure 2. Resulting from this process are the thicknesses of the layers 3 through 6, with  $d_1 = 5$  96.0 nm,  $d_2 = 20.1$  nm,  $d_3 = 24.0$ , and  $d_4 = 130.0$  nm.

When this process described in the foregoing is applied to layer systems 3 that are or will be applied to substrates 1 with grooves or channels 7, this leads to incorrect and unacceptable results, as shown 10 in Figure 3. It is no longer possible to obtain satisfactory consistency between calculated reflection values and the curve 32 for the measured reflection values of the curve 31.

In order to achieve satisfactory results and also to be able to measure reliably the layer thicknesses in layer systems on substrates 15 with grooves, in accordance with the invention the light losses in perpendicular incidences on the sample are taken into account, whereby these light losses occur due to the grooves in the substrate. In accordance with the invention, preferably the inphase overlap of electromagnetic partial waves at the grooves are calculated, and thus 20 their interference is calculated. Thus in this exemplary embodiment the width  $b$  and the depth  $t$  of the grooves 7 are also included in the variations of the parameters.

The consistency of the calculated reflection curve 41 with the measured reflection curve 42 that can be seen in Figure 4, that is, the consistency between measurement and calculation, results when the width  $b$  and the depth  $t$  of the grooves 7 are consistent with the width  $b$  and the depth  $t$  of the groove on the measured sample.

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In one exemplary embodiment, when the geometry of the grooves is not known, the inventive method is used to determine parameters in the layers 3 through 6 as follows: groove depth  $t = 40.5$  nm, groove width  $b = 501.0$  nm, and thicknesses  $d_1 = 95.0$  nm,  $d_2 = 20.6$  nm,  $d_3 = 22.9$  nm, and  $d_4 = 130$  nm.

In the exemplary embodiments for a layer system 2 for a CD-RW described in the foregoing, the layer 3 comprised ZnSSiox, layer 4 comprised AgInSbTe, layer 5 comprised ZnSSiox, and layer 6 comprised ALTi. These layers were located on a substrate or blank 1 that had grooves 7 and that comprised polycarbonate.

However, it is also possible to determine the groove geometry of the substrate initially independently from the layer thicknesses in order to learn the groove geometry. In accordance with this, first the layer thickness is measured in accordance with the inventive method. In the layer system used in the exemplary embodiment described in the foregoing, for the layers 3 through 6 when the groove geometry is known, where  $t = 41$  nm,  $b = 485$  nm, and  $a = 1600$  nm, the layer

thicknesses are as follows in this order:  $d_1 = 96.5$  nm,  $d_2 = 17.1$  nm,  $d_3 = 21.3$  nm, and  $d_4 = 100$  nm.

In another exemplary embodiment, a layer system 2 as described in each of the two preceding embodiments is initially applied to a substrate without grooves and the layer thicknesses are pre-specified or measured with the values  $d_1 = 96.4$  nm,  $d_2 = 20.1$  nm,  $d_3 = 24.0$  nm, and  $d_4 = 130$  nm. In accordance with this, the same layer system is now applied to a substrate with grooves 7 using the now known sputter rates and the groove geometry is selected for the inventive method as free parameters, that is, the width  $b$  and the depth  $t$  of the groove are selected. In this manner it is possible to determine the groove geometry with the inventive method. When the layer thicknesses are as stated, when the measured and calculated reflection curves are consistent in accordance with Figure 4, a groove depth that results is  $t = 47.2$  nm and the groove width that results is  $b = 362.4$  nm. In this embodiment of the method, the spectral information on the groove geometry, which information is contained in the reflectance, is reinforced by the applied layers.

In accordance with an additional exemplary embodiment of an inventive method, it is also possible to determine the groove geometry over the surface of an entire CD in a localized manner.

Figure 5 illustrates one measurement result for determining the groove depth  $t$  over a polycarbonate blank that has grooves. No layers

are applied to the blank. Based on the differences in the groove depths  $t$  over the surface of the substrate, it is possible to rapidly and simply identify production errors during the injection molding of the substrates or blanks.

5                   The inventive method and a measuring device based on said method can be used with great advantage in production facilities for optical storage media. The reflection and/or transmission light intensity values are resolved spectrally, measured in the zero order of diffraction, and either the layer thicknesses and the groove geometry are calculated simultaneously therefrom or, if the groove geometry is known, the layer thicknesses are determined. When the actual values of the layer thicknesses calculated in this manner deviate from the target values, the values for the correcting variables in the production facility, for instance the sputter rate and/or the sputter time, can be subsequently determined or adjusted and forwarded to the production facility.

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15                   The invention was explained in the foregoing using preferred exemplary embodiments. However, for one skilled in the art, variations and embodiments are possible without departing from the inventive thought. It is also possible to employ the inventive method using transmission measurements instead of the reflection measurements used in the exemplary embodiments described in the foregoing.

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Patent claims

1. Method for determining the thickness of at least one layer provided on a substrate by measuring reflection and/or transmission light intensity values of zero order of diffraction as a function of the wavelength and by calculating the reflection and/or transmission light intensity values using an iteration model that depends on the individual layer parameters, whereby said layer parameters are modified to effect correspondence between the measured values and the calculated values, and whereby said substrates have geometric structures, the geometric dimensions of which are used as additional parameters of said iteration model.

2. Method in accordance with claim 1, characterized in that interferences that occur due to said geometric structures are used for additional parameters.

3. Method in accordance with claim 1 or 2, characterized in that the geometric dimensions of said structures are determined.

4. Method in accordance with any of the preceding claims, characterized in that the calculated data for the layer thicknesses (n) and/or geometric structures are used for regulating production

processes for applying at least one layer to a substrate and/or for developing substrate structures.

5. Method in accordance with any of the preceding claims, characterized in that the substrates are blanks for data storage media.
10. 6. Method in accordance with claim 5, characterized in that geometric structures are embodied as channels in said blank.
15. 7. Method in accordance with any of the preceding claims, characterized in that at least one layer is an information-carrying layer.
8. Method in accordance with claim 7, characterized in that said information-carrying layer is a metal alloy that can be modified by the energy from a beam of light between two phases.
9. Method in accordance with claim 7 or 8, characterized in that said information-carrying layer is embodied between two buffer layers.
20. 10. Method in accordance with any of the preceding claims, characterized by use during the manufacture of optical data storage media.

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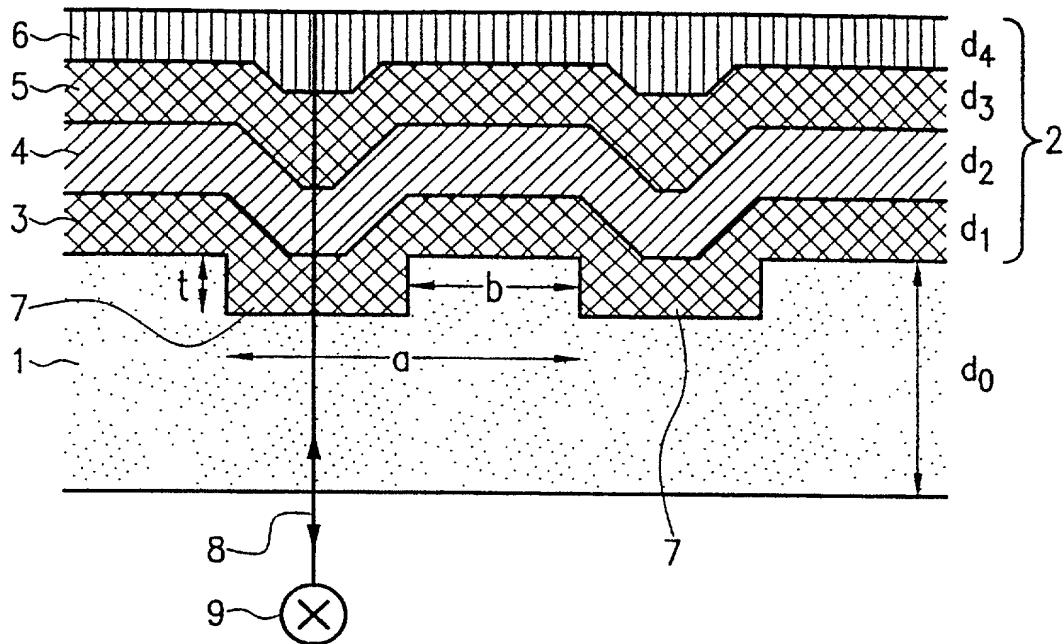
Dr. Ralf Hartwig et al.  
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FIG. 1

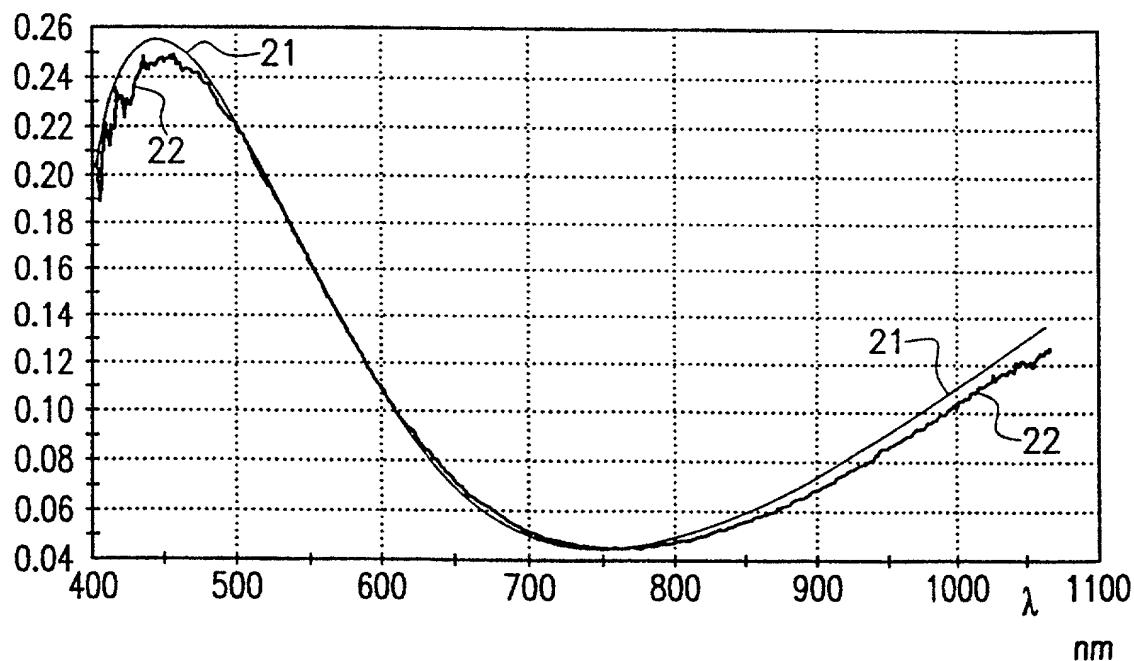


FIG. 2

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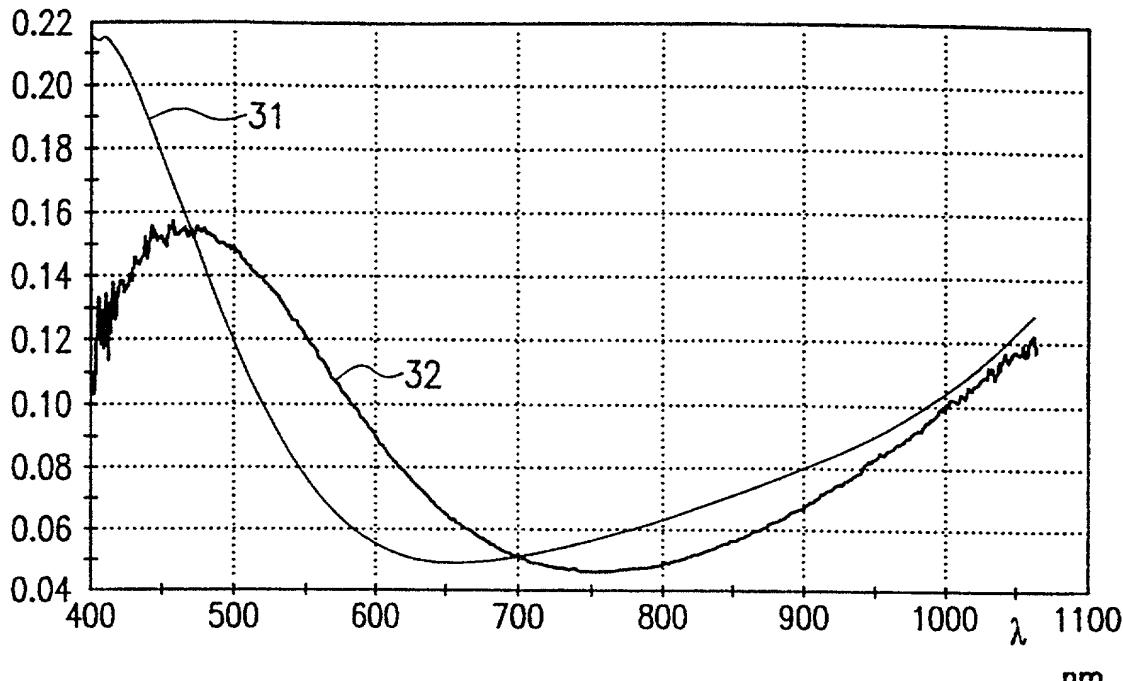


FIG.3

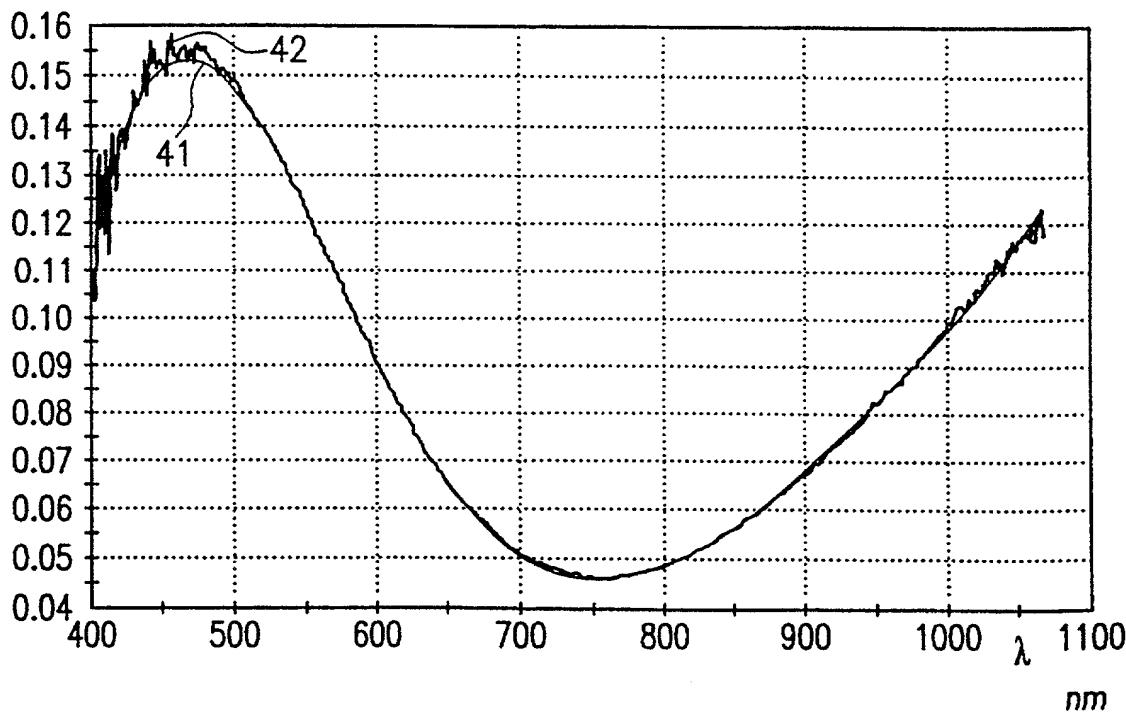


FIG.4

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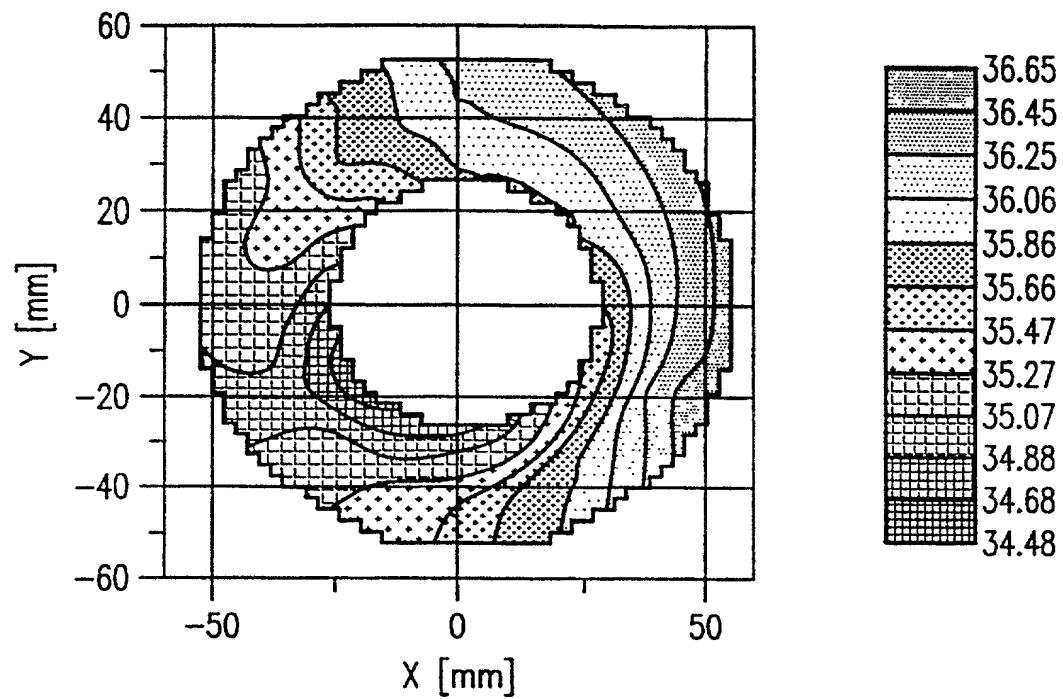
Dr. Rolf Schmid & Co  
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FIG.5

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought of the invention entitled:

METHOD FOR DETERMINING THE THICKNESS OF A MULTI-THIN-LAYER STRUCTURE

the specification of which

WAS FILED ON November 6, 1999 as International application PCT/EP99/08534 and amended on May 11, 2001 as U.S. Serial Number 09/831,842

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information known by me to be material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

Priority Claimed:  
Yes      No

198 52 323.8 (Number)      Germany (Country)      12 November 1998 (Day/Month/Year Filed)

X

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

(Application Number)

(Filing Date)

I hereby appoint attorney Robert W. Becker, Reg. No. 26,255, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith. Address all telephone calls to (505) 286-3511. Address all correspondence to ROBERT W. BECKER & ASSOCIATES, 11896 N. Highway 14, Suite B, Tijeras, New Mexico 87059.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor: Dr. Rolf Hertling

Inventor's signature

R. Hertling

Date: 21.05.01

Residence: Rosfeld 66, D-52074 Aachen, Germany

DEX

Citizenship: German

Post Office Address: same as above

Full name of second inventor: Wolfgang Schaudig

Inventor's signature

Wolfgang Schaudig

Date: 21.05.01

Residence: Friedrich-Ebert-Strasse 136, D-41236 Mönchengladbach, Germany

DEX

Citizenship: German

Post Office Address: same as above

Full name of second inventor: Dr. Wilbert Windeln

Inventor's signature

Wilbert Windeln

Date: 21.05.01

Residence: Krakener Strasse 24, D-52525 Heinsberg, Germany

DEX

Citizenship: German

Post Office Address: same as above